

This forecast was verified as regards the eastward movement of rain and temperature areas. However, an extensive area of high barometer building up over the Atlantic Ocean from the 16th to 23d was joined on the 20th by a high area that had advanced over the Northern States and Canada, and combined with low pressure over the interior of the country to cause a drift of easterly winds from the Atlantic over the eastern portion of the United States. This resulted in several days of unsettled showery weather that began on the 21st and continued until the 27th.

In the meantime a shallow barometric depression advanced from the Caribbean Sea to the Gulf of Mexico from the 21st to 23d. Pressure continued low over the Gulf until the 25th when two centers of disturbance began to form, one over the west Gulf and the other near the east Florida coast. The west Gulf depression drifted slowly northward over the coast line without developing marked intensity. The disturbance near the Florida coast gradually deepened until the 29th, when a northward movement began and on the morning of the 30th a storm of marked intensity was central off the North Carolina coast. During the 30th the depression deepened rapidly and at 4:20 p. m. a reading of 29.18 inches was reported at Wilmington, N. C., and at the regular evening report of that date a reading of 29.22 inches was reported at that station. Storm advices had been sent to Atlantic ports for several days and storm warnings were displayed on the 30th from Wilmington, N. C., to Cape Cod. Based upon the 4:20 p. m. special report hurricane warnings were ordered from Hatteras to Norfolk. During the 31st the center of disturbance moved slowly northward and at the evening report had passed north of Hatteras where the barometer at the time of the regular evening observation read 29.32 inches. The subsequent course of this storm was northeast near the Middle Atlantic and New England coasts, and it disappeared over Newfoundland the night of August 2.

Concurrent with the passage of this storm along the Atlantic coast of the United States a destructive typhoon visited the China coast in the neighborhood of Hongkong and Canton.

The Jacksonville, Fla., Evening Metropolis, of July 30, 1908, comments as follows regarding this storm:

The storm that the Weather Bureau has been watching for three or four days has at last shown itself, and this morning is approaching the coast line near Wilmington, N. C. At 7 a. m. the wind velocity at North Carolina stations was between 40 and 50 miles an hour from the east and northeast. No doubt the disturbance has given some sailing vessels a hard time. The fact that the storm has at no time been near land, and yet located daily with almost absolute accuracy, shows the exactness with which the Weather Bureau makes its predictions. There are a number of vessels that delayed sailing on account of the display of storm warnings, and they now appreciate the wisdom of their conduct. The Weather Bureau was established to render service. Who will say it is not doing so?

The month closed with moderate temperature from the central valleys over the Atlantic coast States, and exceptionally high temperatures in the northern Rocky Mountain districts, where maximum readings ranged above 100°.

BOSTON FORECAST DISTRICT.\*  
[New England.]

The drought that prevailed thru June continued during the first two weeks of July. During the latter half of July well-distributed showers occurred. Temperature ranged high, and in a number of instances maximum temperatures were the highest recorded in a number of years. Storm warnings were displayed on the 17th and 30th, and there were no storms without warnings.—*J. W. Smith, District Forecaster.*

NEW ORLEANS FORECAST DISTRICT.\*  
[Louisiana, Texas, Oklahoma, and Arkansas.]

Temperature was about or below normal and precipitation was unevenly distributed. But one storm, that of the 30th, appeared on the Gulf coast. Warnings that were justified

were ordered for the Louisiana and Mississippi coasts on the morning of that date.—*I. M. Cline, District Forecaster.*

LOUISVILLE FORECAST DISTRICT.\*  
[Kentucky and Tennessee.]

Temperature averaged near the normal and precipitation was generally below the seasonal average. The longest warm period was from the 12th to 17th, and the longest cool period from the 8th to 11th. There were many thunderstorms, some of which caused local damage, and in Kentucky alone there were 10 or 12 casualties from lightning.—*F. J. Walz, District Forecaster.*

CHICAGO FORECAST DISTRICT.\*  
[Indiana, Illinois, Michigan, Wisconsin, Minnesota, Iowa, Missouri, North Dakota, South Dakota, Nebraska, Kansas, and Montana.]

No warnings were issued and none was required. Temperature was below normal during the first portion of the month, but a warm wave began during the third decade and the period closed with temperature abnormally high. Rainfall as a whole was deficient.—*H. B. Hersey, Inspector and District Forecaster.*

DENVER FORECAST DISTRICT.\*  
[Wyoming, Colorado, Utah, New Mexico, and Arizona.]

Heavy rainfall over an area extending from the Gulf of California to western Nebraska was a feature of the month. In northern portions of Utah and Wyoming the month was unusually dry. Temperature was below normal east and generally above normal west of the Continental Divide.—*F. H. Brandenburg, District Forecaster.*

SAN FRANCISCO FORECAST DISTRICT.†  
[California and Nevada.]

Except at the close of the month when temperatures exceeded 110° in the interior of the State the month as a whole was cool in California. There were many thunderstorms in the mountains. Light showers fell at the beginning of the second decade and from the 10th to 14th showers occurred in Nevada and the Sierra. There were no storm nor frost warnings issued.—*A. G. McAdie, Professor and District Forecaster.*

PORTLAND, OREG., FORECAST DISTRICT.†  
[Oregon, Washington, and Idaho.]

The month was quiet with temperature above and rainfall generally below normal. Periods of high temperature extended from the 6th to 12th, 18th to 22d, and 29th to 31st, the last-named date showing very high temperatures over the eastern portion of the district. No special warnings were issued and none was needed.—*E. A. Beals, District Forecaster.*

#### RIVERS AND FLOODS.

The lower Mississippi River floods of the spring and early summer of the year 1908 were especially remarkable for their extreme duration. They may be said to have begun when the Ohio River flood of February reached New Madrid, Mo., on the 21st of that month. From this time until July 24 either the entire lower river, or some portion thereof, was above the flood stage. The flood stage of 16 feet was first past at New Orleans on March 9, and the river did not again fall to that stage until July 25, a period of 138 days. The following table shows the number of days the lower Mississippi River was at or above flood stage from New Madrid to New Orleans. Comparative figures for the great flood of 1903 are also shown.

These lower Mississippi floods were also remarkable for the fact that for the first time in more than a generation the western tributaries played an important part. As a rule, unless the Ohio River is very active, the floods below Cairo, Ill., are neither prolonged nor dangerous, but during the present year, with the Ohio only moderately active, the floods were of unprecedented duration, altho not so great in volume as those

\* Morning forecasts made at district center; night forecasts made at Washington, D. C.

† Morning and night forecasts made at district center.

of 1897 and 1903. The Ohio River was, of course, a prominent factor, as the floods of February, March, and April in that river, while not unusual, kept the waters of the lower Mississippi at a comparatively high stage, and rendered them more readily responsive to the influence of the western and northern tributaries. Later on the volume was swelled by the May floods of the Arkansas and Red rivers, and again in June by another flood from the same rivers, to which were joined the flood waters from the Missouri and upper Mississippi rivers. Had the Ohio River been in flood in June, a not altogether unprecedented occurrence, the lower Mississippi flood would have been the greatest in its recorded history.

Station.	Flood stage.	Number of days at or above flood stage.	
		1908.	1903.
	<i>Feet.</i>		
New Madrid, Mo.....	34	50	53
Memphis, Tenn.....	33	59	54
Helena, Ark.....	42	66	67
Arkansas City, Ark.....	42	132	82
Greenville, Miss.....	42	66	39
Vicksburg, Miss.....	45	115	60
Natchez, Miss.....	46	104	.....
Baton Rouge, La.....	35	111	.....
Donaldsonville, La.....	28	107	.....
New Orleans, La.....	16	138	85

Following are the detailed reports by the officials in charge of the river districts of Memphis, Vicksburg, and New Orleans.

MISSISSIPPI RIVER FROM CAIRO, ILL., TO HELENA, ARK.

By S. C. EMERY, Official in charge, Local office of the Weather Bureau, Memphis, Tenn.

While no serious floods have occurred from Cairo to Helena during the present season, the river conditions have been very remarkable.

In January a moderate rise kept the river above a normal stage during the greater portion of that month, and from about February 20 to the second week in June, it was above a 30-foot stage at Memphis, except from April 30 to May 10, when it was from one to two feet below. During this time four great rises came into the lower river, each of which carried the water slightly above 35 feet at Memphis and from 44 to 45 feet at Helena. At Memphis the water stood at or above flood stage (33 feet) on fifty-nine days. The greatest number of days with the river above flood stage in any previous year was sixty-five in 1882, while in the great floods of 1897 and 1903 the record was fifty-two and fifty-four days, respectively. At Helena, Ark., it was above flood stage (42 feet) on sixty-six days, which is only one day less than the record for 1903. At New Madrid, Mo., it was above flood stage (34 feet) on fifty days, which is only three days less than the record for 1903. The highest stage at New Madrid during any of the four rises was 36.6 feet on March 20, and the river was above 36 feet on nineteen days. At Memphis the highest stage was 35.6 feet on March 23, and the river was at or above 35 feet on twenty days. At Helena the highest stage was 45.2 feet March 26 and the river remained above 44 feet on thirty days.

From February 25 to June 1 the low, unprotected lands along the river were never sufficiently free from water to permit farming operations to be carried on except to a limited extent, and levee work was entirely suspended for nearly four months.

The first rise reached the head of the district on February 13, giving New Madrid a stage of 36.2 feet on February 28, Memphis 35.1 feet on March 3, and Helena 44.2 feet on March 5. The water then fell slowly for about five days, but had hardly fallen below flood stage at Memphis and Helena, when the second rise came on sending the river to higher stages than had the previous one. At New Madrid it reached 36.6 feet on March 20, Memphis 35.6 feet on March 23, and Helena 45.2 feet on March 26. These two rises came mainly from the Ohio

watershed and it is interesting to note that the movement of flood crests from Pittsburg to Helena occupied exactly eighteen days in both cases. The time interval to Cairo was ten, to Memphis fifteen, and to Helena eighteen days. Timely warnings were issued for these rises and estimates as to the maximum height of the flood were given out from six to nine days in advance. On the first rise the errors in the estimates given out were in no case greater than 0.2 foot. On the second rise there was an error of 0.4 foot at New Madrid and Memphis, while an accurate estimate was given for Helena fourteen days in advance of the arrival of the crest.

The third great rise set in at the head of the district about April 10, with the water still close to flood stage over the whole course from Cairo to Helena and considerably above flood stage at all points below. This rise gave New Madrid a stage of 36.2 feet on April 15, Memphis 35.2 feet on April 20, and Helena 44.6 feet on April 22. The crest of this rise moved from Cairo to Helena in eight days, thus making the same time as the two preceding.

The fourth rise came on very slowly and was caused mainly by heavy downpours of rain over Illinois, Indiana, and the region drained by the small tributaries that empty into the Mississippi River between Cairo and Memphis. The river rose so slowly that the crest did not reach Memphis until twenty days after the river began to rise at New Madrid. The maximum stage at New Madrid was 36.1 feet on May 21, at Memphis it was 35.3 feet on May 25, and at Helena 44.4 feet on May 27. Exact estimates on the height of the flood at Memphis and Helena were made seven days in advance of the arrival of these crests. Owing to reports of severe floods in the upper tributaries, considerable alarm was felt in some portions of the district in regard to their possible effect on the lower river, and the demands made on this office were at times very great. To satisfy these demands and to allay as much as possible the unnecessary alarm caused by sensational reports, river bulletins giving the exact conditions at the time, and what might be expected in the future, were extensively distributed each day thruout the district with very good results.

The heavy and long-continued rains thruout the lower Missouri watershed during June, caused severe floods in the Mississippi River from near St. Louis to Cairo, and these floods, together with the congested condition of the lower portion of the river, prevented any material decline in the Mississippi from Cairo to Helena during the entire month of June. From the 1st to the 25th, the fall only amounted to about 1½ feet, the stage on the latter date being practically 29 feet.

The records of this station, which extended back to 1872, show only five June rises of equal proportion to the one experienced in this district in 1908. The years with June stages higher than those of the current year were 1872, 1892, 1893, and 1903, and the stages were as follows:

Table of June stages.

Year.	Feet.
1872.....	31.6
1883.....	30.2
1892.....	34.4
1893.....	33.5
1903.....	33.0
1908.....	30.7

In 1873 the river was very high in June, but not so high as in the present year.

As the crest stages of the present season were about five feet below the extreme high-water mark, the levees afforded ample protection to the St. Francis and Reelfoot basins into which very little water escaped. The levees were at no time considered in danger of breaking, tho there were one or two places where bank erosion caused some anxiety on account of the close proximity of the levee to the river. The farming interests outside of the levee on the Arkansas side of the river

and on the lowlands and islands on the Tennessee side suffered great loss on account of the delay in planting, and the people occupying those lands were put to the expense and inconvenience of taking up a temporary residence elsewhere until the water subsided. In many places planting was entirely discontinued for the season and in the lower portion of the district a considerable area of tillable land was submerged until near the end of June.

The money losses due to the high water were about \$800,000, and they would have been larger had it not been for the warnings and bulletins issued by the Weather Bureau. These warnings enabled the farmers to move stock and other portable property to places of safety before it was too late. They also saved many the expense and trouble of moving when such action was not necessary. Farmers were also benefited in being saved the expense of replanting after the receding of the water following the several rises, for without the knowledge obtained thru the Weather Bureau, the work of planting would have gone on, only to have the land again covered and the crop ruined by the next succeeding rise.

Engineers and contractors engaged in levee work kept constantly in touch with the Bureau and in this way were saved the expense of prematurely moving their several camps to the low ground.

#### MISSISSIPPI RIVER FROM HELENA, ARK., TO VICKSBURG, MISS. YAZOO RIVER.

By W. S. BELDEN, Official in charge, Local office of the Weather Bureau, Vicksburg, Miss.

In point of duration the flood that began in the lower Mississippi River in the first decade of February was the most remarkable on record. The flood was due principally to four rises out of the Ohio River and four distinct rises out of the Arkansas River. The rises that came out of the Ohio culminated at Cairo, Ill., February 26, March 18 and 19, April 13 and 14, and May 20, with crest stages between 44.9 and 45.5 feet in each case. The first rise out of the Arkansas crested at Little Rock, Ark., April 15 and 16 with a stage of 23.3 feet; the second reached a stage of 21.0 feet April 27; the third 22.3 feet May 16, and the fourth, which furnished a volume of water much greater than the first three combined, kept the water near or above 25 feet on the Little Rock gage from May 28 to June 22.

At Arkansas City, Ark., in the upper portion of this district, the Mississippi River was continuously above flood stage for one hundred and thirty-two days, and at Vicksburg, in the lower portion of the district, the river was at or above flood stage for one hundred and fourteen days. The following table of river data for Vicksburg shows clearly the unprecedented flood conditions of this year:

TABLE 2.—Floods of long duration at Vicksburg, Miss.

Year.	Highest stage.	Month.	Period continuously above flood stage, 45 feet.	Last date above flood stage.
	Feet.		Days.	
1874 .....	45.7	May .....	23	May 15.
1882 .....	48.8	March .....	37	April 15.
1884 .....	49.0	March .....	78	May 18.
1890 .....	49.1	April .....	94	May 19.
1891 .....	48.1	April .....	64	May 9.
1892 .....	48.4	May .....	78	July 5.
1893 .....	48.3	May .....	44	May 20.
1897 .....	52.5	April .....	70	May 29.
1898 .....	49.4	April .....	26	May 5.
1899 .....	47.3	April .....	31	May 2.
1903 .....	51.8	March .....	58	April 30.
1904 .....	46.9	April .....	17	May 2.
1906 .....	47.2	April .....	19	May 5.
1907 .....	49.7	February .....	32	May 31.
1908 .....	47.9	June .....	114	July 8.

In 1907 the water was above flood stage for a total of 43 days, due to three distinct rises. In other years the total num-

ber of days with the water above flood stage is the same as the number of days with water continuously above flood stage.

From the table it will be noted that the river was continuously above flood stage longer than ever before, and that in only one other year, namely 1892, was the water above flood stage later than May 31.

Approximately 500 copies of the river bulletin were issued daily thruout the flood period, being distributed by steamboat captains to planters up and down the river and by mail to nearly all post-offices in this district. The daily bulletin was also telephoned or telegraphed regularly to Greenville and Natchez and to several smaller places, where it was posted for the benefit of the public.

The first flood warning was issued February 20, stating that the flood stage would be exceeded at Arkansas City in about a week. On February 27 the stage at Arkansas City was 42.5 feet, or 0.5 foot above flood stage. On March 2 flood stage was forecast to be reached at Vicksburg by March 13, and on March 12 and 13 the river was 0.1 foot above flood stage. On March 18 the following forecast was issued:

The crest of the rise now nearing Cairo will reach Arkansas City in about 10 days, with a stage of 48.5 feet. At Greenville, Miss., a crest stage of 42.5 feet is expected, and at Vicksburg the maximum stage will be close to 46.5 feet.

On March 28 Arkansas City reported 48.2 feet, Greenville 42.5 feet, and Vicksburg 46.6 feet. During the first two weeks in April the water receded very slowly from Helena to below Vicksburg.

The water continued to recede slowly below Helena for two weeks subsequent to May 1, but by May 19 the river was again rising thruout the district as the result of the last swell out of the Ohio which set in at Cairo May 5. The last and most phenomenal rise out of the Arkansas was first registered on the Fort Smith, Ark., gage May 24, and on the Little Rock gage two days later. This rise in conjunction with the already long-continued flood on the lower Mississippi produced a very serious condition below the mouth of the Arkansas River. The river bulletin of May 27 contained this forecast:

As the result of the rise coming out of the Arkansas, a stage of slightly more than 50 feet is now indicated at Arkansas City by June 2, close to 45 feet at Greenville a day later, and about 48 feet at Vicksburg June 7.

The crest stages of the season, with dates of occurrence, were as follows: Arkansas City, 49.9 feet, or 7.9 feet above flood stage, June 2 to 4; Greenville, 44.7 feet, or 2.7 feet above flood stage, June 4 and 5; and Vicksburg, 47.9 feet, or 2.9 feet above flood stage, June 6 to 10, inclusive. Subsequent to the crest stages the water fell very slowly, the fall amounting to only 1.9 feet in twenty days at Vicksburg, or less than 0.1 foot per day.

On June 27 it was predicted that the water would pass below flood stage at Vicksburg by July 5. Flood stage still obtained July 4, after which the rate of fall increased steadily.

The upper Yazoo River was high in February and March, and the water was above flood stage at Swan Lake, Miss., from February 19 to March 16, the crest stage of 27.4 feet, or 3.4 feet above flood stage, occurring on February 29. At Greenwood, Miss., flood stage was not reached by several feet. Back water in the lower Yazoo Valley was an important factor in producing the high stages at Yazoo City, Miss., where the rise was very slow from February 17 to March 22. Heavy rains in the vicinity of Yazoo City from March 22 to 24 caused a rise of 1.5 feet in two days, and to 26.0 feet, or 1.0 foot above flood stage, March 24, after which the river fell very slowly, passing below flood stage April 9. However, the water continued above 21 feet on the Yazoo City gage until June 30.

The immense levees on both sides of the Mississippi River from Helena southward, effectively protected hundreds of thousands of acres of very rich agricultural lands. At many places the water stood from 10 to 15 feet against the embankments for months, while planters and tenants were busily

engaged in seeding and tending their crops. There was considerable damage to growing crops from seepage water, especially on Davis Island, which is protected by a private levee; but as a rule the seepage water did not extend far inland from the State and Federal levees, and its detrimental effects can probably be overcome to a large extent, in future floods, by drainage systems to swamps and bayous. There has been no material change in the levees since the flood of last year, and during the recent flood wave-wash was somewhat damaging to those on the Mississippi side of the river. The amount of cultivated land lying between the river and the levees from Helena to about 25 miles above Vicksburg is relatively small, hence losses caused by the flood were comparatively light in that stretch of the river, but the back water in the lower Yazoo Valley proved to be very disastrous. Tillable lands were overflowed for a distance of 50 miles up the Yazoo Valley, and many large plantations in Issaquena, Warren, and Claiborne counties were covered with water until the latter part of June. The lateness of the flood was its most damaging feature. When the water receded the season was too late to permit of bringing a crop of cotton to maturity, and fully 35,000 acres of farm lands in the Yazoo Valley and contiguous to Vicksburg were thus affected.

It became necessary to move nearly 1,000 head of horses, mules, and cattle from the overflowed districts near Vicksburg, but no stock was reported drowned as the warnings of the Bureau were closely heeded. The warnings were also the direct means of saving not less than \$8,000 worth of cotton seed that would otherwise have been planted and subsequently ruined by overflow. Fences and buildings in the overflowed area were more or less damaged, but the stage of the water was not sufficiently high to cause material injury by erosion. In many cases lands were greatly enriched by deposits of sediment. Back water caused an entire suspension of traffic on the Yazoo and Mississippi Valley Railroad between Kelso and Holly Bluff, Miss., a distance of 13 miles, from about March 1 to August 1, some time being required to repair the roadbed subsequent to the subsidence of the flood.

Very few of the negro tenants moved from the overflowed plantations since the houses and cabins are raised four or five feet above the ground, but the enforced idleness placed nearly all in straightened circumstances at the end of the long siege. The Federal Government, thru the War Department, issued 10-day rations on July 4 to 4,473 persons in Issaquena, Warren, and Claiborne counties at a cost of \$2,869.31, and again on July 17 rations for thirty days were issued to 5,600 persons in the same territory at a cost of \$17,332. It was expected that gardens and some late crops would in a measure meet the needs of those tenants that could not otherwise provide for themselves when the rations were consumed.

Losses resulting from the flood in this district were as follows:

*Losses from floods in Vicksburg-Yazoo River district, 1908.*

Property (exclusive of crops) destroyed.....	\$75,000
Crops.....	250,000
Damage to soil by erosion and deposition.....	None.
Suspended business (including wages).....	1,500,000

Total losses.....	1,825,000
Property saved by flood warnings.....	35,000

That so small an amount of property was saved thru the Weather Bureau warnings was not due to any defects in the warnings themselves, but rather to the effectiveness of the levee system. In previous years the levees were not so complete and extensive as they now are, and the warnings of the Weather Bureau usually found property of great value that must either be removed or lost.

MISSISSIPPI RIVER FROM VICKSBURG, MISS., TO MOUTH. ATCHAFALAYA RIVER.

By I. M. CLINE, Official in charge, Local office of the Weather Bureau, New Orleans, La.

The flood in the lower Mississippi and Atchafalaya rivers,

which commenced in February, and reached its maximum June 19 and 22, 1908, exceeded all previous records for duration of high water. The Mississippi reached a stage of 20 feet at New Orleans, which was within 0.4 foot of the high-water record of April 6-7, 1903. A stage of 39.7 feet was reached at Melville, on the Atchafalaya, which was 1.5 feet above the previous high water record.

On February 24, 1908, the stage of the Mississippi at New Orleans was 13.3 feet, and the following warning was issued:

The Mississippi River, below Vicksburg, and the Atchafalaya, will rise; a flood stage of 16 feet will be reached at New Orleans, and 34 feet at Simmesport and Melville by March 4.

The water rose steadily and reached the stages forecast, as follows: Simmesport, 34 feet, March 2; Melville, 34 feet, March 7; New Orleans, 16 feet, March 9. Warnings were then issued regularly until the end of March, advising the public, ten days in advance, as to what stages to expect. Warnings were issued March 30 for the passage of the crest of the high water then in sight, with stages of 46.6 feet at Natchez by March 31; 35 feet at Baton Rouge, 39.5 feet at Simmesport, 37 feet at Melville by April 4, and 17.9 feet at New Orleans by April 5. The crest past with stages as follows: Natchez, 46.9 feet, April 3; Baton Rouge, 35.3 feet, April 4; Simmesport, 40.3 feet, April 9 (with a stage of 39.8 feet, April 4), and Melville, 36.9 feet, April 8 (with a stage of 36.8 feet, April 4). The Mississippi and Atchafalaya rivers then remained nearly stationary until the middle of April. On April 16 the following warning was issued:

A fresh rise, now coming down the Mississippi River, will prolong the high water below Vicksburg for two or three weeks, and is likely to cause a further rise at New Orleans to about 18.5 feet, and, should high southeast winds occur, a still further rise would result.

A stage of 18.5 feet was reached at New Orleans on May 1, and southeast winds backed the water up to 19.1 feet, May 6, after which the river remained high, with a slight fall until May 20, when the gage at New Orleans showed 18.6 feet. On May 20 the following warning was issued:

As a result of rises now coming, the Mississippi, below Vicksburg, and the Atchafalaya will continue high until the middle of June, and, if levees hold, stages are indicated as follows: Natchez, 48 to 48.5 feet; Baton Rouge, 38.5 to 39 feet; Simmesport, 45.5 feet; Melville 40 feet; and should brisk southerly winds prevail during the passage of the crest, a stage of 19.5 to 20 feet may be reached at New Orleans.

The following stages were reached: Natchez, 48.9 feet, June 14; Baton Rouge, 39.6 feet, June 16; Simmesport, 45.2 feet, June 19; Melville, 39.7 feet, June 23; and New Orleans, 20 feet, June 19 and 22. With the exception of a few days, the water stood above 18 feet on the gage at the foot of Canal street, New Orleans, from April 6 to July 15, covering a period of one hundred days.

The levees of the Mississippi and Atchafalaya rivers had been raised and materially strengthened since the high water of 1903. There were, however, some weak places, and there were places subjected to unusual strain during high water, all of which were strengthened as a result of the warnings of the Weather Bureau.

They withstood the remarkable strain of more than three months of continuous high water without a break, except below New Orleans. The successful carrying of this vast volume of water without more breaks in the levees may be attributed partly to the warnings of the Weather Bureau, which kept the public on the alert, raising and strengthening the levees wherever weak spots were found to exist.

The first break in the levees of the Mississippi occurred in the right bank of the river, on the Beka Plantation, 14 miles below New Orleans, early on the morning of June 6. The break was discovered about 7:30 a. m., when only a few feet in width. The banks crumbled rapidly and, notwithstanding the fact that two hundred workmen were assembled and put

to work with the greatest possible dispatch, the crevasse was 35 feet wide at 7 p. m., at which time it was believed that its spread had been checked. Cribbing was put in around the crevasse, but the bank continued to give way, and on June 8 the opening was 75 feet in width. The water by this time had covered the Rio, the Beka, and the Stanton plantations, almost totally damaging the crops growing thereon, aggregating about 30,000 tons of cane. On the night of June 9 the cribbing, which had been constructed across the crevasse, was swept away, and on June 10 the break was reported to be from 90 to 100 feet in width. On June 12 four hundred men were at work building cribbing and endeavoring to close the crevasse. The work was carried forward vigorously under the direction of the State board of engineers, and the crevasse was successfully closed June 26, just twenty days after the break occurred. On June 15 a small break in the levee, less than two feet in width, was discovered on the right bank of the Mississippi, about eight miles below New Orleans. Workmen, with material from the crevasse six miles farther down the river, were rushed to the scene, a mud-box forty feet in length was constructed, and the break was closed.

South of Vicksburg all bottom lands not protected by levees (known as "batture lands") were flooded and crops damaged.

The damage caused by high water in the Mississippi and Atchafalaya rivers may be summarized as follows:

(1) The destruction of 100 feet of levees on the Mississippi River below New Orleans.

(2) The destruction of sugar-cane crops below New Orleans which it is estimated would have produced 30,000 tons of cane. The destruction of cotton crops on the "batture lands" south of Vicksburg which ordinarily produce 20,000 bales of cotton.

(3) No reports of damage to farm lands by erosion or deposit have been received.

(4) Business was suspended for about four weeks on three plantations below New Orleans, but the laborers from these plantations were employed in repairing the breaks in the levee. Laborers from the "batture lands" were used elsewhere.

#### THE ARKANSAS AND RED RIVER FLOODS.

As stated in the MONTHLY WEATHER REVIEW for May, 1908, the heavy rains from the 22d to the 24th, inclusive, of that month, were responsible for the great floods in the lower Arkansas and the Red rivers. These heavy rains were followed by others during the first ten days of June; the fall in the two rivers, which were still above flood stage, was checked, and another rise was started that finally culminated about the middle of the month in the highest stages of the season.

The floods in the Arkansas River and tributaries above Fort Smith, Ark., were not nearly so pronounced as during May, and the losses were only about \$45,000, mainly thru enforced suspension of business. Warnings were issued whenever possible, and one on June 3 for the Arkansas River was particularly effective.

The lower Arkansas flood was one of the longest and most destructive on record. There were three distinct swells, each lasting from four to six days, beginning on May 25, June 4 and 13, respectively. At Dardanelle, Ark., the river was above the flood stage continuously for twenty-six days, and at Little Rock, Ark., for twenty-seven days. Warnings were issued frequently and they were well verified. There was no loss of life and very little of live stock, as the warnings enabled the farmers to take all necessary precautions. The crop losses were heavy. About 40,000 acres of cotton lands were overflowed, and the losses in cotton alone amounted to about \$2,000,000. Much of the damage occurred thru the breaking of levees. The White River was also in flood for several days.

From any viewpoint the flood in the Red River was beyond all precedent. Nothing in the recorded history of the valley can compare with it in point of duration, high stages, extent of overflow, and amount of damage. The flood stage was first

reached at Denison, Tex., on May 25, and from that time until nearly the end of July either all, or some portion, of the river was above the flood stage. At Denison the highest stage was 32.5 feet on May 26, 10.5 feet above the flood stage and 8.9 feet above the highest previous stage of record. At Arthur City, Tex., the highest stage was 43.2 feet, on May 28, 16.2 feet above the flood stage and 6.2 feet above the high-water mark of May 10, 1890. At Fulton, Ark., and Shreveport, La., record-breaking stages were prevented by the breaking of the levees above Fulton. Below Shreveport all previous records were exceeded.

Particular attention is invited to the warnings issued by the Weather Bureau for this flood. They were begun well in advance, and were so specific and decisive in their character as to leave no room for doubt or hesitancy on the part of those interested. Thousands of lives and many millions of dollars worth of property were in imminent danger, and there was no time for delay. No lives were lost, but the property losses were enormous, and they would have been much greater had the warnings failed in any respect.

The money value of the losses and damage along Red River were about \$16,200,000, divided as follows:

Property, excluding crops.....	\$3, 600, 000
Crops .....	8, 500, 000
Erosion of lands (in excess of benefits).....	1, 600, 000
Suspension of business, etc.....	2, 500, 000
Total.....	16, 200, 000

#### FLOODS IN THE RED RIVER AT AND ABOVE SHREVEPORT, LA.

By J. W. CRONK, Official in charge, Local office of the Weather Bureau, Shreveport, La.

In several parts of the Red River Valley this was the most disastrous flood on record. Only by persistent and exhausting labor expended in repairing and raising levees was it possible to save any part of the valley in this section from an overflow.

In the Texas and Arkansas sections, southward from Denison, Tex., all levees were broken, and practically all crops were destroyed, and there was also great damage to bridges, buildings, railroads, and other property.

In Louisiana, by very hard work, the State levees to the north of Shreveport were held intact, thereby saving some 200 square miles from overflow.

Below Shreveport the State levees were broken at three places—at Taylortown, La., on the east bank, and at the "Dixie" and "Riverdale" plantations, on the west bank of the river. As the result of these three breaks several railroads were heavily damaged, and the crops were completely destroyed on notably rich farm lands over an area of 200 or more square miles.

Altho the flood losses were more or less heavy in all parts of the valley, there is no doubt that they would have been far greater had it not been for the warnings of the Weather Bureau. These warnings were early and urgent, and it is especially gratifying to note that there was no loss of life, altho a large number of dwellings were either flooded or washed away. Losses in stock were small, and these losses were mainly due to gross neglect of the warnings. On each and every day of the flood the Weather Bureau was in close touch with the people in all parts of the valley, and many thousands of specific questions, involving the protection of property, were satisfactorily answered. Besides the general saving of live stock, there was a large quantity of other property in the flooded districts, such as farm implements, furniture, food-stuffs, etc., that it was possible to save. In many instances dwellings and other structures, including bridges, were weighted with iron and stone or other heavy material, and their loss thereby prevented.

Many of the working class in this valley are in a destitute condition, as a result of the flood, and the Government and



the people expended more than \$100,000 to relieve the situation by the purchase of food and of seed for food crops.

The widely extended heavy rainfall of May 23 and 24 over the watershed above Arthur City was the principal cause for the main part of the flood. Comparatively little rainfall was reported at that time in eastern Oklahoma and Arkansas, where the floods of the Red River usually originate, but heavy rains from May 11 to 14, over the entire watershed, had previously caused a flood of noticeable proportions in the vicinity of Fulton and more or less high water at other points, so that the Red River was already full over a considerable part of its length before the flood waters from above Arthur City had been added. Heavy rains at various other times during the last of May and the first half of June also added a large volume of water to the river, thereby prolonging or increasing the flood at many places.

Owing to the wide extent of the flood it was necessary to issue an unusually large number of flood warnings.

The first warning on May 24, Sunday, gave notice of the "coming of unusually high flood stages" at Denison and Arthur City, the river to rise more than 11 feet, or above the flood stage of 27 feet, at Arthur City on Monday, and to continue to rise for several days. The special caution was added that "extra efforts should be immediately made to remove the people and stock from all unsafe places in the upper valley."

The cooperation of the press in the dissemination of this and other warnings was of especial benefit.

As early as May 25 a flood warning for a stage of 32 feet and over at Fulton was thoroly disseminated. Three days later the public was warned that "no preparations should be neglected to prevent loss of life in Arkansas from any possible sudden rises to unknown stages." Three days later another warning was issued for a crest stage somewhat above 36 feet at Fulton, but this stage was not reached, as a very large volume of water broke thru embankments just above Fulton, swept across the country by a shorter channel, and reached the Red River again at points below Fulton. Reliable reports state that the highest known flood stages were recorded during this flood within about 4 miles of Fulton, that is, above the broken embankments. It was in this section that the Iron Mountain Railway suffered a heavy loss, several miles of roadbed being washed away.

The crest stages of the flood at the river stations of the Weather Bureau were as follows:

TABLE 3.—*Crest stages of flood on Red River.*

Stations.	Flood stage.	Crest stage.	Date.	Above flood stage.
	<i>Feet.</i>	<i>Feet.</i>		<i>Days.</i>
Denison, Tex.....	22	35.5	May 26	3
Arthur City, Tex.....	27	43.2	May 28	19
Whitecliffs, Ark.....	20	29.0	May 16	42
Fulton, Ark.....	28	34.1	June 2	45
Shreveport, La.....	29	35.2	June 15	26

Careful estimates of losses due to the floods this year in the Red River appear below:

*Losses by flood on Red River above Shreveport, La.*

Property loss (excluding crops).....	\$3, 000, 000
Value of crops destroyed.....	6, 000, 000
Damage to lands (in excess of benefits).....	1, 500, 000
Suspension of business.....	2, 500, 000

Total.....	13, 000, 000
Value of property saved by Weather Bureau warnings.....	4, 500, 000

THE FLOOD BELOW SHREVEPORT, LA.

By I. M. CLINE, Official in charge, Local office of the Weather Bureau, New Orleans, La.

The Red River below Shreveport reached a stage of 30 feet at Alexandria, La., toward the latter part of April. During

the early part of May the river either rose slightly or remained about stationary. Warnings were issued May 20 for a 36-foot stage at Alexandria by June 1. This stage was reached May 29, and the public was then advised to prepare for a stage of 38.5 feet at Alexandria by June 8. On June 9 warnings were issued for a stage of 38.5 to 39 feet by June 19. A stage of 38.9 feet was recorded June 18 and on June 20 warnings were issued for a stage of 39 to 39.5 feet by June 23. A stage of 39.6 feet was recorded on June 23, and the public was advised to prepare for a stage of 40 to 40.2 feet within three days. From this date until the passage of the crest of the high water warnings were issued two to three days in advance, advising as to what stages might be expected, and on July 3 warnings for a stage of 42.2 feet at Alexandria by July 6 were issued, this being the last warning issued for rising water.

The highest stage recorded was 41.8 feet on July 6, which was 3.6 feet above the previous high-water record. The flood warnings were based, in a measure, on the levees holding, and in some instances the stages reached were 0.2 to 0.4 of a foot below the stages forecast, as a result of water flowing out thru breaks in the levees and being carried away thru other channels.

Several breaks occurred in the levees along the Red River. One occurred near Westdale, De Soto Parish, La., June 9, flooding a large area. There was also a break in the vicinity of Creighton, La., June 12, which overflowed a large area of land and caused other damage. About 3 a. m., June 14, two breaks occurred in the levee on the left bank near Moncla, Avoyelles Parish, La., and much land was overflowed. There was a break in the left bank at Tarrytown, 14 miles below Shreveport, in Bossier Parish, at 3 a. m., June 15, which flooded 100,000 acres of land. Hundreds of people were rendered homeless and it was stated that the damage could not be estimated. Another break in the levees occurred below Shreveport, in Caddo Parish, about 6 p. m., June 16, and several plantations were flooded. Estimates placed the flooded area at 250,000 acres. On June 18, about 1 a. m., a break occurred in the levee near Alexandria, on the plantation of Major Fred Seip. The water from this crevasse overflowed more than 4,000 acres of land and rendered one hundred families homeless. On June 25 a break occurred seven miles above Alexandria and a considerable area was flooded. A large volume of water was flowing thru crevasses on the Johnson and Cooper places above Alexandria July 6, at which time the stage at Alexandria was 41.8 feet. Had it not been for the crevasses the stage of 42.2 feet forecast for Alexandria would no doubt have been reached.

In looking for an explanation as to the causes of the unprecedented high water at Alexandria it appears that the volume of water which came down the Red River was not of itself sufficient to have caused the stage reached. The Mississippi and Atchafalaya rivers, into which the Red River discharges, were high and back water from the floods in these streams caused a very slow discharge of the flood waters from the Red River and their consequent congestion for some distance up the Red River. This effect was noted at Alexandria in the early stages of the flood.

The damage caused by overflows along the Red River was very great. The losses amounted to several millions of dollars, which may be summarized in general terms as follows:

(1) The destruction of levees in several localities. Buildings, household effects, and live stock of considerable money value were washed away, and a great number of people were rendered homeless. Railroads near the Red River suffered much damage. Several miles of track were inundated, roadbeds were washed out in places, and traffic had to be suspended or changed to longer routes. The railroads in Louisiana probably suffered to the extent of more than half a million dollars.

(2) The bottom lands along the Red River, planted to cotton

and corn, were overflowed to a great extent and the growing crops destroyed.

(3) Many thousand acres of land suffered to some extent from erosion or deposit.

(4) Several hundred laborers were thrown out of employment, but many of these secured employment after a few weeks in other parts of the State where available labor was not sufficient to meet current demands. The loss from the suspension of business was quite heavy.

(5) Regarding the value of the warnings of the Weather Bureau, it is impossible to express the same in money terms. As a result of the warnings the levees were raised and strengthened, and the public had time to transfer movable property to places of safety. The fact that, with unprecedented high water, there was no loss of life as a direct result of the overflows may be largely attributed to the flood warnings of the Weather Bureau which advised the people of the coming of the high water.

The floods in the upper Missouri Valley were caused by the heavy rains in the early days of the month of June, 1908, and before they subsided the highest stages on record occurred in the Missouri River and its northern tributaries as far east as the Montana-North Dakota line. Great damage was done, and in some sections of central Montana railway traffic was suspended for more than three weeks.

#### FLOODS IN THE UPPER MISSOURI RIVER.

By C. D. REED, Official in charge, Local office of the Weather Bureau, Sioux City, Iowa.

Heavy rains occurred in Montana during the first week in June and there was a general downpour on the 4th and 5th, which caused most of the smaller streams to swell to stages before unknown, thereby damaging irrigation ditches and plants, eroding the soil, drowning live stock, and paralyzing railway and telegraph service. Destructive floods occurred in Missoula, Gallatin, Madison, Park, Meagher, and Rosebud counties.

By the 6th and 7th the water had collected and begun to do damage at points along the larger streams, particularly the Missouri and Milk rivers. For a long distance above and below Fort Benton, Mont., on the Missouri River, the tracks of the Great Northern Railway were under 9 feet or more of water, and in many places the grade was washed away, together with the telegraph poles and wires. At Fort Benton a stage of 18 feet was reached between the morning of the 6th and the morning of 7th. Nearly the entire town was overflowed and boats were used in the streets. The oldest inhabitants could not remember having heard of such high water. The highest stage heretofore recorded was 11 feet on June 14, 1892. Twelve miles below Fort Benton, where the Teton and Marias rivers flow into the Missouri, the water was reported to be 32 feet above low-water mark and a clean sweep was made of everything, including livestock, while the people themselves barely escaped to the hills.

On this section of the Missouri River the following very conservative estimate of the damage has been made:

Property destroyed (excluding crops).....	\$150,000
Crops destroyed.....	40,000
Damage to farm land.....	100,000
Enforced suspension of business.....	20,000
<b>Total.....</b>	<b>\$310,000</b>

The Milk River at Havre rose steadily until it reached a stage of 16.3 feet on the 9th, which is higher by 1.3 feet than the previous high water of April, 1899. The flood stage of 9 feet has reference to interests nearby, but not in the town, which is protected from flood by a railway grade, so that a stage of 20 feet could be reached before damage would begin. For a short distance above, and for 25 miles below the town, the damage by the deposit of mud was great and it is thought that a number of years will be required to restore the soil to

its normal condition. This land is used chiefly for hay, but some other crops are raised. Railway train service between Havre and Helena was not resumed for twenty-six days after June 4, mainly on account of high water along the Missouri. The interference with telegraph service in the incipient stages of these floods made it impossible to distribute warnings anywhere in the State of Montana.

The crest of the flood in the Missouri River flattened rapidly as it past eastward, but it was at the same time augmented by continuous rains in eastern Montana and the Dakotas, so that the crest appeared to move much slower than usual. From Fort Benton to Wolf Point, Mont., is usually not more than five days' run for flood crests, but in this case the highest water at Wolf Point occurred seven days later than at Fort Benton. The highest water at Wolf Point was 12.8 feet on the 14th, which was 0.7 foot higher than any previously recorded stage. From Wolf Point to Bismarck, N. Dak., is usually not more than two or three days' run for a flood crest, but the highest water at Bismarck in this instance was not reached until the 19th, five days later than at Wolf Point. This was due to further augmentation by heavy rains mainly within the confines of North Dakota. The highest stage, 15.1 feet at Bismarck, was 0.4 foot higher than any previously recorded summer stage, in a period of sixteen summers.

On June 9 and at intervals until the crest reached Sioux City warnings and information of the progress of the flood were sent to interests on the lowlands from Running Water to Meckling, S. Dak. Between Running Water and Springfield, S. Dak., and on the bottoms southwest of Tabor, S. Dak., there pasture large numbers of live stock which, with moderately high water, may find refuge on slightly elevated areas, but with higher stages would be lost. These lands begin to overflow when a stage of 13.5 feet is reached at Running Water. The highest reached at Running Water was 15.9 feet on the 22d, a stage that had been accurately forecast on the 19th. The Chicago, Milwaukee, and St. Paul Railway track was under water and washed out in places between Running Water and Springfield, and train service was not resumed for ten days from June 11. Aside from the loss to the railroad, amounting to about \$1,000, no damage is known to have occurred. The deposit of silt on the bottom lands in that section was considered rather more beneficial than otherwise, as the pastures began growth with renewed vigor as soon as the water subsided.

In spite of the fact that the river at Bismarck was higher by 2.5 feet than it had been during the past three years, the highest stage reached at Sioux City was the same as it had been for the two previous years, 15.2 feet, on June 23.

In the Omaha river district the Missouri River was about 1 foot above the flood stage, but no material damage was done.

The same general conditions that caused the floods in the upper Missouri watershed extended southeastward thru the Plains States, and below the mouth of the Platte River conditions were much more serious, especially in Kansas and northwestern Missouri, where the flood was the third in magnitude in their history, taking rank immediately after those of 1844 and 1903. In point of duration it stands alone. The daily press published the fullest account of these floods, and the following reports are designed to cover only such details as are necessary to preserve a permanent record.

#### MISSOURI RIVER BELOW PLATTS MOUTH, NEBR., KANSAS RIVER AND TRIBUTARIES.

By P. CONNOR, Official in charge, Local office of the Weather Bureau, Kansas City, Mo.

As a rule, when there is a flood in the lower Missouri there is also one in the Kansas River, as both result from heavy rains in adjacent States. This year was no exception.

At the beginning of June all rivers in this district were at ordinary stages. Excessive rains in southern Nebraska on the 2d started a rapid rise in the Big Blue River. The flood stage

of 14 feet was reached at Blue Rapids, Kans., on the evening of that date, and the crest of 23 feet at 5 p. m. of the 4th. A recurrence of heavy rains in the same territory on June 5 again sent the falling stream upward to a crest height, on the morning of the 6th, of 34.2 feet, which was within 0.3 foot of the highest record, that of 1903. This was foreshadowed in a telegram sent the observer at Blue Rapids at 10:55 a. m., June 5, which read:

Very heavy rains in southeast Nebraska last night; four inches Fairbury indicate dangerous outlook for Blue Rapids and Blue Valley generally.

These rains also started a moderate flood in the Republican River, coincident with that in the Blue, reaching a crest of 21.6 feet in early morning of June 6 at Clay Center, Kans., 3.6 feet above flood stage.

Anticipating a flood in the Kansas River from the waters of those tributaries and the rains in prospect, a telegram was sent the river observer at Manhattan, Kans. (at the junction of the Blue and Kansas rivers), on the forenoon of June 4, advising that flood stage would be reached at that place on the 5th, the stage then being 14.7 feet and the flood stage 18 feet. On June 6, at 8 a. m., the stage was 18.6 feet, and warnings were sent to all post-offices between Manhattan and Kansas City and between Kansas City and Boonville, Mo. Warnings were repeated daily from the 7th to the 11th, inclusive, and on the latter date the following was published:

The Kaw shows a slight fall at Kansas City and decided fall at points west. There will not be much change in the flood level at Kansas City during the next twenty-four hours. The tendency of the Kaw will be downward, serving to check a rising tendency in the Missouri.

The latter river had risen steadily at St. Joseph from June 6, averaging 0.9 foot per day, and reached 14.4 feet at 7 a. m. on the 11th, which was very much higher than was indicated by the changes and stages above it. The volume of water coming down more than counterbalanced the diminishing Kaw, causing a slight rise in the flood level at Kansas City until 4 p. m., when the gage showed 28.6 feet. The river began to fall during the night of the 11th, and by 6 p. m. of the 12th the flood level had been lowered 0.6 foot. But this fall was not to go on uninterruptedly.

Heavy rains in the Kaw Valley on the night of the 11th started another wave in that stream, so that on the morning of the 12th warnings had to be repeated to Kaw River points. The following message was sent to Topeka:

Weather very unsettled. Outlook justifies assumption that flood stage will again be reached at Topeka Sunday (14th). People should be cautious.

Manhattan was also notified that flood was again indicated for that place. The local information given out for Kansas City read:

The Missouri River at Kansas City has fallen 0.3 foot below the maximum at 6 p. m. last evening. A decided fall is shown in the Kaw, but in view of the heavy rains last night and the liability of more, people should look upon the river situation with extreme caution and be slow to resume operations where the water has receded. There will not be much change in the flood level in the next twenty-four hours.

On Saturday morning, June 13, the following was published:

The heavy rains of last night will probably raise the flood level at Kansas City to about 30 feet by Sunday afternoon. The Kaw will respond to the rains, and the discharge will be retarded by the high stage of the Missouri.

The rivers in the vicinity of Kansas City continued rising during Sunday the 14th, reaching a crest height of 30.3 feet on the Missouri gage and 29.6 feet on the Stockyards gage Monday morning, June 15. After that the tendency was downward with a few slight fluctuations.

It will be seen from the foregoing that the flood was made up of two distinct waves. It not only attained a remarkably high stage, but it was a most remarkable flood, so far as the Missouri is concerned. The Kansas was out of its banks at

Topeka and Lawrence from June 7 to 15; the Missouri was out of its banks at St. Joseph from June 4 to July 10, and at Kansas City from the night of June 7 to July 5, and on the 9th, 10th, and 11th. The rains were so timed that the river at St. Joseph did not vary one foot in height from June 11 to July 1.

The crest of the Kaw flood reached Manhattan at 4 p. m. June 7, 24.8 feet; Topeka at 3 a. m. June 9, 28.0 feet; Lawrence at 4 p. m. June 9, and in the vicinity of Kansas City about 9 p. m. June 10. The rate of crest movement from Manhattan to Topeka was 2.1 miles an hour; from Topeka to Lawrence 2.8 miles an hour, and from Lawrence to the vicinity of Kansas City 1.7 miles an hour, an average of 2.2 miles an hour. It is believed, however, that the crest movement in the latter section was retarded by the influence of the Wakarusa River which empties into the Kaw about six miles east of Lawrence. The crest of the 1903 flood moved at the rate of 2.6 miles an hour.

Rains started the Blue River on another rise on the 17th, and a stage of 25.7 feet was reached on the morning of the 20th. This was anticipated by a warning on the 18th. Altho the river was nearly 12 feet above flood stage at Blue Rapids, it only augmented the Blue and Kaw at Manhattan to one foot above flood stage.

Heavy rains in northwestern Kansas on the 15th, 16th, and 17th caused the greatest flood at Beloit, Kans., of which there is record, the water reaching a stage of 33.25 feet at noon on the 20th, 2 feet higher than the flood of 1903. The river was out of its banks on the 15th and 16th, but fell to an 8-foot stage on the 17th; it began rising rapidly on the 18th, going out of its banks again on the morning of the 19th. It fell below flood stage on the 22d.

The volume of rain that fell in the Kansas and Nebraska portion of the Kaw Basin during June was 11 per cent less than fell in May, 1903.

The Blue River cut a new channel about one-half mile above Manhattan, and water past thru it at a stage of about 13.5 feet. At the higher stages more water past thru the new channel than the old one, the former being very much the wider.

The Missouri River did considerable cutting in places, notably at Atherton and Sibley, Mo., below Kansas City. Some correspondents write that the land has been damaged by erosion or deposit, while others state that the benefits offset the damage. It appears to be a fact that the flood was a positive benefit of a permanent nature in many localities along the Missouri. Its long duration with only slight changes in its level from day to day, left the bottoms overflowed with very muddy and sluggish water so that sedimentation was very great. It has been found that local depressions have been raised as much as 3½ feet, while the common level of bottom land for long stretches has been raised a foot or more.

The situation at Kansas City was met very successfully. As soon as the first warning was issued, which was on Saturday, June 6, the community took the matter seriously and went to work vigorously. As a result all goods and household effects in the bottoms were transferred to higher floors or other places of safety, and the railroads took precautions that nothing susceptible of damage by water would be caught by the flood this year. Any damage that resulted from the flood was absolutely unavoidable. It was not a very destructive flood. It did not come with a mad rush as did the flood of 1903, when the river rose 7.5 feet in twenty-four hours, with the water previously all over the bottoms.

Armourdale, a portion of Argentine, and Harlem were depopulated, and the bottoms were entirely submerged. The water partially surrounded the Union Depot, but it did not go over the floor of the waiting room and ticket office, in contrast with the condition in 1903 when the water was 7 feet high in the ticket office, altho only 4.7 feet higher than in the present



year. This was due to the fact that the volume of water was less in the Kaw this year.

Much of the East Bottoms, especially that portion in which is located the larger interests, was protected from complete inundation by strenuous efforts on the part of the Kansas City Southern Railroad, ably assisted by the Missouri Pacific. The roadbed of the Kansas City Southern passes between the more densely populated portion of those bottoms and the Missouri River, the tracks being several feet higher than the general level of the bottoms. Hundreds of men were kept at work day and night with a construction train, placing bags of sand along the roadbed. These tracks and those of the Chicago, Milwaukee and St. Paul Railway afforded the only eastern outlet during the high water.

Floods appear to be on the increase in this section, and it may be difficult to find a satisfactory reason for it. Had this been a great timber region its clearing and development might in a large measure account for their recurrence, but it is part of the Great Plains whose aspect has been changed only by the cultivation of the soil. From 1844 to 1881 is a long stretch of years, yet no flood of any consequence occurred in that epoch. In the latter year a flood occurred which furnished the standard high-water reference for the community for the next two decades, yet the stage was only 26.3 feet. It proved to be, however, the greatest flood in fifty-eight years. Then followed the great flood of 1903 with its 35-foot stage, 14 feet above flood stage. In 1904 the river reached 25.2 feet, and in the present year 30.3 feet. Thus within five years occurred three most important floods, two of them being greater than any in the history of Kansas City, excepting that of 1844.

Man's desire to possess the earth has often led him to make a mistake when dealing with the forces of nature, and perhaps it is so in these flood matters. It must be admitted that heavy rains occurred in times past as well as in more recent years, and during those times flood waters were taken care of by channels shaped and dimensioned by the compelling forces of erosion where nature held sway. Now conditions have changed. The natural water courses have been encroached upon by obstructions, damming, and reclamation processes until, in many instances, they are barely more than half the original dimensions. A board of Government engineers, in a report dated January 23, 1904, made the following statement of the conditions at the mouth of the Kaw, or Kansas, River: "The channel has been encroached upon by riparian owners until its normal average width of about 850 feet (minimum 540) as shown by meander lines of 1856, is reduced to an average of about 590 feet, with a minimum in one place of 420 feet." The width of the Missouri at Kansas City, while it may conform to established harbor lines, has been narrowed from a 2000-foot channel to less than 1000 feet. At other river towns and cities the same spirit has been at work, and in these so-called improvements is to be found one of the real causes of recurring and destructive floods.

The following is a recapitulation of damage along the various streams and the value of warnings:

*Blue Valley.*—Damage to property other than crops, perhaps \$200,000; value of crops destroyed, etc., \$400,000; damage to farm land by erosion or deposit, \$100,000.

*Republican Valley.*—Damage to property other than crops, very light; value of crops destroyed, etc., \$300,000; damage to farm land by erosion or deposit, not much.

*Solomon Valley.*—Damage to property other than crops, not great; value of crops destroyed, etc., \$300,000; damage to farm land by erosion or deposit, considerable in the upper portion, not much in the lower portion; loss by enforced suspension of business, not much.

*Smoky Hill.*—Eastern portion, value of crops destroyed or damaged, \$100,000.

*Kaw Valley.*—Damage to property other than crops, about \$55,000; value of crops destroyed or damaged, \$1,500,000; loss thru suspension of business, not including the vicinity of Kansas City and Topeka, about \$30,000.

*Missouri Valley.*—Plattsmouth, Nebr., to Boonville, Mo., damage to property other than crops, about \$75,000; damage to crops of all kinds, \$4,120,000; damage to farm land by erosion or deposit, \$300,000; loss thru enforced suspension of business, not including Kansas City, \$90,000. This loss pertains chiefly to business, as employees were engaged protecting against the flood and lost no time.

The total losses, excluding Kansas City, were as follows:

Property (exclusive of crops) .....	\$300,000
Crops .....	7,320,000
Soils .....	500,000
Business suspension .....	200,000
Total .....	8,320,000

The long duration of the flood in the Missouri Valley has made it especially severe. It not only injured what was in the ground, but prevented replanting with anything.

The damage at Kansas City was very small compared with that caused by the flood of 1903, in fact the damage to property was very light considering the size of the flood. Twenty-three business institutions in the bottoms (some in Kansas City, Mo. and some in Kansas City, Kans.) reported a total damage to property of only \$91,500. The same number report total loss by enforced suspension of business of \$168,000, and value of property saved by the flood warnings of the Weather Bureau \$1,324,000. The railroad losses were only about \$350,000.

Next to Kansas City and vicinity, the city of Topeka, Kans., was the greatest sufferer. The total losses amounted to about \$700,000, and it is estimated that property to the amount of \$1,000,000 was saved thru the Weather Bureau warnings. The greatest damage probably lies in the depreciation of real estate values in the flooded districts, partly on account of actual damage to buildings, and partly on account of the feeling generally expressed that other floods will occur in coming years. On this account the county commissioners, after the waters had subsided, reduced the assessed value of real estate in North Topeka from \$1,968,515 to \$1,484,135.

The following editorial published in the Lawrence, Kans., Gazette of June 12, 1908, testifies to the general excellence of the work performed by the Weather Bureau during the flood:

The Weather Bureau at Topeka did most excellent service during the flood and before it. The information the Gazette gave out came from there, and it was never wrong. Mr. Jennings gave out information that saved hundreds of thousands of dollars to the people along the Kaw Valley, and he and his department deserve the thanks of those in the track of the flood. From the very beginning he told hours, and once or twice days ahead just what was going to happen. And not only that, he also told just when it would happen at a given point. Time after time wild rumors would fly over the country, and every time the Gazette got track of one, it had it run down and stopped by news direct from Jennings. Sunday evening he told the Gazette just how much higher the river would go, and it went just that high and stopped. He also said that it would reach its highest point here not earlier than noon of Tuesday, and at noon Tuesday it had reached its highest point, and at 3 o'clock it was falling. The Gazette gave the warning sent it by Mr. Jennings to every farm house in the valley near Lawrence that could be reached by telephone, and everyone obeyed the message, and got out of the way of harm. The Weather Bureau saved more money during this one flood than it will cost to run it for years.

From Boonville eastward to the mouth of the Missouri River experiences were similar to those farther westward. Flood warnings were first issued on June 7 and crest stages as follows, were recorded: Glasgow, Mo., 27.2 feet on June 18, flood stage, 18 feet; Boonville, Mo., 28.2 feet on June 18, flood stage, 20 feet; and Hermann, Mo., 25 feet on June 20, flood stage, 24 feet.

The floods in the Mississippi watershed above Cairo, Ill., excluding the Missouri, were not general. There was a disastrous flood in the Minnesota River, and a moderate one in the Mississippi above the mouth of the Minnesota, but from Lake Pepin to the mouth of the Des Moines River there was no high water. Below the mouth of the Des Moines flood conditions were general during June, and much damage of the usual character was done, much of it being due to the prolonged duration of the flood. The following account of the floods in the Minneapolis, Minn., district, including the Minnesota River, was prepared by Mr. U. G. Purcell, Official in charge of the Local office of the Weather Bureau at Minneapolis, Minn.:

#### FLOODS IN THE MINNESOTA RIVER.

By U. G. PURCELL, Official in charge, Local office of the Weather Bureau, Minneapolis, Minn.

Beginning with May 11, 1908, and continuing to the end of the month, frequent heavy rains occurred over the Minnesota section, producing the heaviest average monthly rainfall on record for the section. The precipitation was particularly heavy in the central Minnesota River watershed. At Winnebago and New Ulm the rainfall during May was over 11 inches, and at Mankato and St. Peter over 9 inches. During June the downpours were even heavier than in May, but they were of less frequent occurrence. The monthly rainfall was again especially heavy in the central Minnesota River watershed, in the upper Minnesota watershed and thence northeastward over a number of counties of the Mississippi watershed. At St. Peter the monthly rainfall was over 12 inches, at Mankato, Lake Crystal, New Richland, and Morris about 11 inches, and at Little Falls nearly 10 inches. These unusually heavy downpours caused the Mississippi River to rise above the flood stage at Fort Ripley on June 10, and to continue in flood at that point until the 15th, with a maximum stage of 11.0 feet on June 11. At St. Paul the river was above the flood stage from June 2 to 17, inclusive, with a maximum stage of 15.0 feet on the 14th. It again went above the flood stage on June 27, and continued in flood until July 5, with a maximum stage of 16.8 feet on June 29. This latter flood came from the Minnesota River.

The Minnesota River at Mankato, rose steadily from the middle of May, and rapidly during the last four days of that month, to 17.5 feet, 0.5 foot below the flood stage, on May 31. It then fell steadily to 10.1 feet on the 18th of June. It rose 2 feet from the 18th to the 22d, and then 4 feet in twenty-four hours, from the 22d to the 23d, as a result of a tremendous downpour of more than 5 inches in twenty-four hours, which occurred in Waseca County on the 20th. Excessive rains in a number of counties on the central Minnesota River watershed from the 20th to the 23d, caused the stage to increase rapidly to 21.2 feet on the 26th, and it then decreased slowly to 17.8 feet, or 0.2 foot below the flood stage, on the morning of the 30th. The water receded at the rate of 0.5 to 0.9 foot per day from June 30 to July 5. The rise of the water in the first flood in the Mississippi River was so gradual that no serious damage was done. Until June 12 the regular daily bulletins kept all interests fully informed. On that date a special warning was issued, forecasting a stage of 15 feet at St. Paul within forty-eight hours. This stage was reached at that place on the morning of the 14th. The dwellers on the river flats in St. Paul were much inconvenienced by being driven from their homes, and considerable damage was caused to lands and crops by overflow on the river bottoms.

The flood in the Minnesota River which caused the second and greater flood in the Mississippi River at St. Paul was very destructive in the Minnesota Valley. Timely and frequent warnings were issued until the crest of the flood past the various cities in the lower valley from Mankato to St. Paul, and all movable property was saved, but all crops in that portion of the valley were destroyed. The loss of bridges and fences

and the damage to highways were enormous. At Mankato and at other points the railroads suffered heavily from washouts and interruption to train service. On the Mississippi the loss was confined principally to suspension of business in the sawmills from Minneapolis to St. Paul and at Little Falls, and to dwellers on the low levels, who were driven from their homes and compelled to live in tents and box cars for several days.

The money value of property destroyed or amount of damage, exclusive of crops and including railroads, is estimated at over \$750,000. The money value of crops destroyed or damaged is estimated to be at least \$300,000. Damage to farm lands by erosion or deposit, \$50,000. The damage from deposit is thought to be temporary, as the silt was mainly washed from fertile soil and there was very little gravel deposited.

The money value of losses occasioned thru enforced suspension of business, including wages of employees, is estimated at \$200,000.

The money value of property saved by the flood warnings of the Weather Bureau is estimated to be at least \$400,000. No lives were lost as a direct result of the flood, and 90 to 100 lives were saved as a direct result of the Weather Bureau warnings. The city of Mankato suffered severely from an epidemic of fever immediately after the flood, which was thought to have been caused by contamination of the city water supply by flood water.

In the Hannibal, Mo., district the losses of about \$100,000 were principally to crops, and were due to the fact that the extreme duration of the flood prevented any replanting, the high water persisting from May 28 until July 12.

The first warnings for the Mississippi River from below Hannibal to St. Louis were issued on the 7th, and they were repeated daily until after the decline was well marked. The forecasts made from June 16 to 18, inclusive, predicted a crest stage of between 34.5 and 35 feet at St. Louis within a few days, and a maximum stage of 34.9 feet occurred on the 20th and 21st. The river was above the flood stage of 30 feet from June 9 until July 8, inclusive. The following statement relative to the extent of the overflow and the losses resulting therefrom was prepared by Mr. O. C. Burrows, of the Local office of the Weather Bureau at St. Louis. The figures given include that portion of the Missouri Valley east of Kansas City not previously mentioned.

#### FLOODS BETWEEN HANNIBAL, MO., AND ST. LOUIS, MO.

By O. C. BURROWS, Assistant, Local office, Weather Bureau, St. Louis, Mo.

The levees along this portion of the Mississippi, while inadequate, afford greater protection from overflow than do those along the Missouri, and have been raised and strengthened since the flood of 1903. As a result much valuable farm land, that would otherwise have been inundated, was protected. The American Bottom, a tract 95 miles in length, extends from below Alton, Ill., to the vicinity of Chester, Ill., on the Illinois side of the river, with few levees of importance, and it was in this district that the greatest damage from the flood occurred. The greater portion of the tract was under from one to ten feet of water which in places extended back eight or ten miles to the bluffs. The area submerged between Hannibal and Chester was about 300,000 acres, at least half of which was under cultivation. The total area overflowed, between Boonville, Mo., and the mouth of the Missouri River and between Hannibal and Chester on the Mississippi River, was about 600,000 acres, nearly 50 per cent of which was under a high state of cultivation. In addition to the farm land which was inundated, there were a number of towns and cities wholly or partly flooded. On the Missouri River, Cedar City, Craig, Corning, Woolridge, and Overton were flooded, and on the Mississippi portions of Alton, Venice, Madison, National City, Granite City, East St. Louis, Ill., and St. Louis

were submerged. The inundated district in St. Louis was confined to Front street and to railroad tracks on low ground in the northern portion of the city. A few railroad embankments gave way in East St. Louis, and small areas were flooded. The loss in the two cities was, therefore, nominal, and resulted mostly from the suspension of business in the overflowed districts. The loss of, and damage to, property for the entire district was about \$500,000, and the value of the crops destroyed was about \$4,000,000. Damage to farm lands by erosion and deposit amounted to about \$100,000. The loss sustained thru the suspension of business amounted to about \$200,000. Timely warnings, issued in advance of this flood, gave ample opportunity for the removal of all portable property and live stock from the threatened districts to places of safety, and it is estimated that property to the value of \$750,000 was saved by heeding them. There was no loss of life due directly to the flood, so far as press reports show. Between Louisiana, Mo., and the mouth of the Missouri River the stages were not alarming.

More moderate floods occurred in the Mississippi River from Chester to Cairo, Ill., for which warnings were issued as occa-

sion required. While these warnings were frequent and accurate, much damage of an unavoidable character was done. The season was so late that the floods were much more destructive than usual, except in the vicinity of Chester, Ill., where the damage was small. Below Chester the losses and damage amounted to about \$850,000, principally to growing crops. There were also local floods in small streams in various portions of the country during the month of July, due to heavy rainfall. Considerable damage was done in interior New York, northern and western Maryland, southern Virginia, southeastern Nebraska, Colorado, and southwestern Idaho.

The highest and lowest water, mean stage, and monthly range at 207 river stations are given in Table IV. Hydrographs for typical points on seven principal rivers are shown on Chart I. The stations selected for charting are Keokuk, St. Louis, Memphis, Vicksburg, and New Orleans, on the Mississippi; Cincinnati and Cairo, on the Ohio; Nashville, on the Cumberland; Johnsonville, on the Tennessee; Kansas City, on the Missouri; Little Rock, on the Arkansas; and Shreveport, on the Red.—*H. C. Frankenfield, Professor of Meteorology.*

### SPECIAL ARTICLES, NOTES, AND EXTRACTS.

#### RAIN-MAKING IN NEW ZEALAND.

An article on experiments in rain-making in the New Zealand Times of Wellington, October 23, 1907, lately came to the attention of the Editor as another illustration of the waste of public money consequent upon popular ignorance and superstition. Of course it is not to be expected that every one should appreciate the positive knowledge that constitutes meteorology, but it is to be hoped that every illustration of this kind may contribute something to the education of the public.

We understand that both climatology and meteorology are combined in the Meteorological Office of New Zealand, but that of course the former branch of the science is likely to receive the greater amount of attention. It would seem that the people and the Government initiated the rain-making business at Oamaru in the North Otago district which had been suffering from a drought for several months; and it was only left for the Meteorological Office to send the Rev. D. C. Bates, F. R. M. S. and Government Meteorologist, to watch the experiments and report on the results. Of course he knew that the production of rain by cannonading is hopeless, and it would have been proper to regard the experiment as a stupendous farce. But it had a tragic aspect, since on the one hand he, on arriving at Oamaru, seems to have been hailed as a plenipotentiary armed with dynamite, guncotton, gunpowder, special railway trains, motors, and a posse of troops to do his bidding, in the presence of thousands of strangers. On the other hand, the local rain-making committee had caused the churches to offer up prayers for rain and for the success of the experiments, and now stood ready to denounce both religion and science if rain did not follow the cannonading. It seemed like a contest between paganism and intelligence in which forbearance, silence, and patience are the better weapons.

The official report by Mr. Bates has been published almost entire in the local papers of New Zealand and we reprint it as a most instructive scientific and educational document. The result should go far to prevent other communities from making such foolish experiments and should draw the attention of every one to the need of saving the rainwater after it has fallen. It is a case where conservation is possible and production impossible.—*C. A.*

#### REPORT UPON THE DRY PERIOD AND RAIN-MAKING EXPERIMENTS AT OAMARU, NEW ZEALAND.

By D. C. BATES, Government Meteorologist. Dated Wellington, N. Z., September, 1907.

The district of North Otago, often called after its chief town, the Oamaru district, is sheltered on the west, north, and south

by mountainous ranges, which condense and precipitate on their windward slopes much of the moisture borne by the winds from these directions, and it must therefore depend chiefly on easterly weather [winds] for its rains. The northeasterly and southeasterly winds which accompany cyclonic disturbances and are usually laden with water-vapor, sweep up the Kakanui and Waitaki valleys, causing the most abundant rains to fall over the district. In some seasons, however, these atmospheric movements do not extend their influences so far south, and then, while the North Island gets more than the usual amount of rain, those parts of the South Island depending upon them are liable to experience droughts. A prolonged dry period of an unusually severe character for any part of New Zealand, extended over the Oamaru district during the years 1889, 1890, and 1891. The years 1897 and 1898 were also very dry, and the last period of deficient rainfall from January, 1906, to August, 1907, was 45.7 per cent below the sum of the average monthly rainfalls for the eighteen months included.

Rainfall observations for the Meteorological Office have been kept at Windsor Park, Oamaru, since 1892 by Messrs. E. and W. Menlove; also at Kauroo Hill, near Maheno, by Messrs. R. A. Chaffey, C. de V. Teschemaker, and A. French from January 1, 1890. While in Oamaru I learned that much older records, extending from 1866 to 1893, had been kept by the late T. W. Parker, esq., Resident Magistrate, and these were presented to the Meteorological Office by Mr. H. Edwards, who had continued Mr. Parker's work for a few years. Another valuable record, from 1888 to the present, with many interesting details of the effects of the weather upon pastoral and agricultural affairs, was also loaned us by Mr. Jas. Macpherson of Totara Station.

The annual rainfalls for Oamaru are as follows:

TABLE 1.—Annual rainfall at Oamaru, New Zealand, 1867 to 1906.

Year.	Inches.	Year.	Inches.	Year.	Inches.	Year.	Inches.
1867.....	23.58	1877.....	26.75	1887.....	26.28	1897.....	14.12
1868.....	25.73	1878.....	20.26	1888.....	29.10	1898.....	15.96
1869.....	13.38	1879.....	25.26	1889.....	14.33	1899.....	27.41
1870.....	32.82	1880.....	20.37	1890.....	14.15	1900.....	20.36
1871.....	16.32	1881.....	13.47	1891.....	16.60	1901.....	18.79
1872.....	19.93	1882.....	25.67	1892.....	23.03	1902.....	23.56
1873.....	28.00	1883.....	23.23	1893.....	20.04	1903.....	13.37
1874.....	21.79	1884.....	26.82	1894.....	23.71	1904.....	19.62
1875.....	23.39	1885.....	16.81	1895.....	24.26	1905.....	23.26
1876.....	17.20	1886.....	26.36	1896.....	23.75	1906.....	14.81

The average rainfall for these forty years is 21.87 inches;